

MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

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No. 6

Lieut.-General J. F. TENNANT, C.I.E., R.E., F.R.S., President,
in the Chair.

Sir George Errington, Bart., Lackham Manor, and Brooks's
Club, St. James's Street, S.W.;

Edward Robinson, 4 Castelnau Gardens, Barnes, S.W.;

Andrew Simons, Her Majesty's Dockyard Schools, Devonport,
were balloted for and duly elected Fellows of the Society.

The following candidate was proposed for election, the name
of the proposer from personal knowledge being appended:—

Thomas Steele Sheldon, M.B. Lond., Cheshire County
Asylum, Macclesfield (proposed by Rev. T. Harley).

On the Nautical Almanac.

By Lieut.-General J. F. Tennant, C.I.E., R.E., F.R.S.

About a couple of years ago I communicated to the *Observatory* a paper on this subject in the hopes that astronomers with varied experiences would offer suggestions for removing imperfections in our National Ephemeris. The result was very small, but this was not due, I think, to a belief that the Almanac is incapable of improvement so much as to the fact that its weakest points do not force themselves on the notice of those who are resident near its first meridian, and who use it mainly in preparing for or reducing observations for publication.

If we examine the contents of the *Nautical Almanac* we find that we can arrange them under four heads with convenience.

Remarks on above.—The mode of putting the Moon's semi-diameters and parallaxes below the Polar coordinates of the day, adopted in the *Connaissance des Temps*, seems to me convenient. I would add in the same way the mean times of the transits; the phases might, as now, close the month, or be placed at the beginning of the Almanac. I have entirely omitted the Moon-culminating Ephemeris, which in its present form I look on as valueless save for Greenwich. If the times of transit and the coordinates of the Moon could be given for each hour of longitude, somewhat as in the *Connaissance des Temps*, they would be useful; but it is a question if the gain would be worth the cost. If anyone will try to use the present Table of Moon-culminating places for the purpose of determining the right ascension of the Moon's centre, or that of the limb, and the hourly motion, say at Madras, he will be satisfied that there is a more ready way of gaining his object.

As regards the Stars. The list should be greatly increased. There should be no difficulty about this. The *Berliner Jahrbuch* gives a list of the mean places of 622 stars of which the ephemerides are given for some 450, and the *Connaissance des Temps* gives ephemerides for 360. Uniformity would require that the places should be given for mean noon or midnight at Greenwich, and I do not think that this would be practically inconvenient; but as stars are generally observed on the meridian, the present arrangement offers advantages and might stand. Eclipses and occultations should have their elements given so as to facilitate as much as possible the computation of local phenomena. The arrangement of elements of occultations in the *Connaissance des Temps* is the most complete, but that of the *American Nautical Almanac* is more compact, and practically suffices. A similarly convenient form is to be found in Dr. Anton's *Ephemeris*, published at Trieste, in which the data are taken from the *Nautical Almanac*. The mode of giving the elements for eclipses recently in the *Connaissance des Temps*, and, from somewhat similar formulæ, in the *American Nautical Almanac*, seems to me to offer most convenience for use.

I see no reason why the information as to Satellites should be confined to *Jupiter's*, and have included those of all planets known to have any. I should like to see a uniform system for enabling the observer to recognise the configurations. The mode of exhibiting those of *Jupiter's* satellites is unsatisfactory when the times of observation differ from those employed; but there are of course other means of distinguishing these satellites than their positions.

I would suggest further that the Star ephemeris might be made a sub-section so that it could be attached to any of the sections which may be preferred.

2nd. *The Greenwich Ephemeris* would contain

Solar Ephemeris at Transit	...	...	...	...	...	p. i. of month
Lunar Ephemeris, being Moon-culminating Stars, omitting } Lower Transit ...	...	...	...	...	...	} pp. 369-398
Mercury at Transit	...	...	...	...	...	
Venus	..	...	...	...	...	270-273
Venus	..	...	...	...	...	274-277
Mars	..	...	...	...	...	278-281
Jupiter	..	...	...	...	...	282-284
Saturn	..	...	...	...	...	285-287
Uranus	..	...	...	...	...	288-289
Neptune	..	...	...	...	...	p. 290
Eclipses for British Observatories	...	...	...	...	...	401
Occultations at Greenwich	...	...	...	...	...	pp. 441-443
Satellites of Jupiter, Eclipses, &c., for Greenwich	...	...	...	...	...	444-465

I should propose to extract the eclipses of *Jupiter's* satellites, &c., from the general list so far as they are visible in the United Kingdom. I presume in all other matters English astronomers have secured almost all that they especially want, and that any changes will be very trifling.

3rd. *The Nautical Section*.—Considered merely as a portion of the volume this would contain only

Lunar Distances, pp. xiv. to xviii. of mo.

Table for 2nd Difference Correction p. 482

Tables for correcting Lunar Distances for the Earth's figure.

Table for Latitude by *Polaris* pp. 483-485

„ „ Azimuths by „

„ „ Tides 476-479

I have added a table for azimuths by *Polaris* because I think this would be useful to surveyors, and not less so in navigation, especially in low latitudes. I should very much like to see tables, such as those in the *Berliner Jahrbuch*, for correcting lunar distances for the effects of the figure of the Earth; they would be probably rarely used at sea, but would be valued by all careful observers everywhere. As regards tides, I should like to see tide tables given for the principal ports whenever there are data for computing them accurately, as there now are, I believe, for many points on the coast. The cost of mechanical computation would be but trifling, and there seems no reason why London should be the sole tidal station. As a rule I fancy that heights, unless readily convertible to heights over a bar or shallow, would not be of much use to seamen.

Lastly we come to the *Computing Section*. The ephemerides

in this would be latitudes and longitudes, but all data would be referred to the equinox of the beginning of the year when the Sun's longitude is 280° . The contents would be:—

The matter contained in page 1 of the *Nautical Almanac*, save that the mean obliquity and precession should be referred to the above date instead of January 1^o.

The Sun's Longitude, Latitude, and Log Rad Vector ... p. iii. of month.

The Sun's Co-ordinates for Mean Equinox of above date pp. 218-225

The Moon's Latitude, Longitude p. iv. of month.

Empirical Corrections to Moon's Latitude, Longitude ... pp. xv. & xvi. of App.

Mean Longitudes, &c., of Moon and its Node.

Heliocentric Longs., Lats., and Distances, Mercury 226-233

" " " Venus 234-241

" " " Mars 242-249

" " " Jupiter 250-257

" " " Saturn 258-265

" " " Uranus 266-267

" " " Neptune 268-269

Mean Places of Stars 292-295

Bessel's Formulæ of Reduction p. 296

" Day Numbers pp. 297-304

" Independent Constants 305-312

Day of Year, and Corresponding Day of Julian Period.

Latitudes and Longitudes of Observatories.

In the *Berliner Jahrbuch* the latitudes and longitudes of the Moon are only given to one-tenth of a minute. This accuracy would suffice for the Moon, and equally for the smaller planets, but (unless space be wanting) I would propose to give them all to the nearest second. *Jupiter* and the planets beyond should have them given to $0''.1$. In the cases of the planets daily places would be unnecessary, but I would propose that they be given for every fifth day of the Julian Period; thus, in the current year the dates would run January 2, 7, 12, &c. I should be very glad to see the co-ordinates of the planets given for the same dates referred to the same planes as those of the Sun. It does not seem necessary to give corrections of these to the apparent equinox of the day either for Sun or planets, but as regards the latter there would be an advantage in a correction to the equinox of a preceding and succeeding year, say the even tenth years preceding and succeeding. These co-ordinates could be computed as a step in passing from the Heliocentric longitudes and latitudes to the Geocentric right ascensions and declinations.

In the *Nautical Almanac* the places of the stars are referred to the beginning of the fictitious year, but the mean equinox for

other purposes is that of January 1^o. There seems no reason for this variation, and I have proposed that, as in the *Connaissance des Temps* and the *Berliner Jahrbuch*, the beginning of the year should have only one meaning—that is, the moment when the Sun's mean longitude is 280°.

If the values of the day numbers in the *Nautical Almanac* be compared with those of the *Connaissance des Temps*, it will be found that towards the end of January and December there is a considerable difference between the C's and the D's. This is due to the fact that the terms of the expression for Nutation, depending on the longitude of the solar perigee, are omitted in the *Nautical Almanac*. There is also an additional quantity E omitted which is applicable to the right ascensions, and whose maximum value is $\pm 0''.05$ or $\pm 0^s.0033$. All these are very small quantities, but it does not seem right that they should be neglected when we consider the accuracy with which modern observations are reduced, as well as the fact that in the *Nautical Almanac* smaller periodic terms than some of these are retained. The quantities g , G , and f of the Independent Constants also require correction for the effects of the same terms. It appears unnecessary to continue Airy's day numbers, which are not required for use with the recent Greenwich Catalogue, and have never been required for the catalogues of other observatories. In fact, Mr. Stone's tables for finding a , b , c , &c., supersede all special calculations for the star numbers if his constants be accepted, and render Bessel's day numbers alone necessary when an ephemeris or several places of a star are required. Where it is a question of reducing single or very few observations of stars, the independent constants are best. The means of applying the terms of Nutation, which depend on the Moon's longitude, and change rapidly, should be given. This can be done in two ways. Their effects on C , D , f , g , and G , can be given separately, or they can be included at once in the daily values. The former plan is theoretically preferable, and I think the effects should be tabulated with the Moon's longitude as argument, for the change of arguments in a day is too great for convenient interpolation of the numbers, and this difficulty is only concealed, and not removed, by the latter practice, which, however, has the authority of the *Berliner Jahrbuch*. When any of the day numbers change sign, passing through 0, the logarithms become so irregular that their interpolation is impossible. In these cases it is desirable to give the natural numbers instead of the logarithms, with some suitable warning. In the *Berliner Jahrbuch* the natural numbers are given in addition to the logs., but this is hardly necessary. In the independent constants, also, $\log. i$ should be replaced by i under similar circumstances.

In what has preceded, I have spoken of the Nautical Section as a part of the General Almanac, but I do not think that the wants of navigation and geography will be met as fully as they should be by this arrangement. I have long felt that a smaller

volume, which should omit all that was not useful to the wanderer, would be a boon; and the existence of various ephemerides, containing selections from the *Nautical Almanac*, with tide tables, and various information as to special ports, shows that the want has been felt in England, though no official attempt has been made to meet it. Elsewhere the case is different. In America, under the title of the *American Nautical Almanac*, a small volume* has been annually published for the use of navigators, and this, again, has been further simplified in two smaller volumes, for the especial use of coasters on the East and West coasts respectively. The German Government have published at Berlin, under the editorship of Dr. Tietjen, a very handy volume called the *Nautisches Jahrbuch*; and more recently the Austrian Government have published at Trieste a volume called the *Astronomische Nautische Ephemeriden*, edited by Dr. Anton, of which the text would seem to be given in more than one of the languages of that Empire. France, too, has begun a series of extracts from the *Connaissance des Temps*, for the use of the Marine. Of these I think the Berlin volume would be far the best type to follow. The arrangement, indeed, is not that which I prefer, but it would be intelligible to those using it. With slight exceptions, it contains all that a surveyor or traveller by land or sea can want. One shortcoming is in the Elements of Occultations, where, though the data suffice for calculating a longitude from an observed occultation, they do not at once do so for predicting the circumstances for a given place, the power of doing which is essential to any systematic use of occultations. In this respect Dr. Anton's volume is more satisfactory. Both should, I think, give the elements and charts for eclipses. I do not think the data for *Jupiter's* satellites are of much use. They may occasionally furnish an approximate longitude when the stay at a station is very short; but for anything like satisfactory observation they require more optical means than the traveller generally has—means requiring carriage facilities which I think would justify our expecting him to adopt a better mode of determining longitude than lunar distances.

Some sixty years ago, a Committee of our Society, under authority from the Admiralty, devised the arrangement of the *Nautical Almanac* substantially as it now exists; small changes have been made, all in the direction of advance, but the lapse of time seems to me to make it desirable that there should be a new committee representative of the interests concerned. And I do not think that the plan of starting the changes determined on, and leaving the matter to official supervision, is quite satisfactory. I should like to see a more permanent consultative

* This is in fact extracted from the General American Ephemeris, which will be found of late years to be divided into sections somewhat as I have proposed. Professor Newcomb has been good enough to send copies of these Nautical Publications through me to the Library.

body, whose duty it should be to receive, consider, and decide on questions of proposed changes. The *Nautical Almanac* comes in contact with such large classes of men scattered over the world, that it is hardly possible that the experience of one or two officials in London can meet all the wants of those using it. It is no reflection, then, on those who have had the guidance of our ephemeris that they have not succeeded perfectly in an impossible task; indeed, that after some sixty years of uncontrolled management, the *Nautical Almanac* is so little behind the times is the best testimony to the care which has been given to it. But we should not be content with this. A Nation whose ships are in every Sea, and whose Colonies surround the globe, should not be content to lag behind, but should be amongst the leaders in giving facilities for its widely-scattered astronomers, mariners, and geographers.

P.S.—The Astronomer Royal has stated that Hansen's Tables include empirical terms, and I believe that some of his coefficients have been determined so as to make the Tables agree with observation; theory, however, prescribed the arguments and the numbers are Hansen's. Two of Newcomb's corrections are purely empirical and have no foundation in theory, and the other three, which I have proposed to print in the *Ephemeris*, arise from changes made in Hansen's data; they may be improvements, but they cannot be considered part of Hansen's Tables.

Note on the Apparent Star Places of the Nautical Almanac.

By H. H. Turner, M A., B.Sc.

In the course of the longitude operations recently undertaken at the Royal Observatory, Greenwich, occasion arose for comparing the places of the circumpolar stars given in the *Nautical Almanac* with those of other almanacs, viz. the *Connaissance des Temps*, the *Berliner Jahrbuch*, and the *American Ephemeris*, which will hereafter be designated *C.T.*, *B.J.*, and *A.E.* respectively. The meridians being different, simple interpolation must be used for such comparisons, except in the case of the *N.A.* and *C.T.*, where the difference of meridians is so small as to render this unnecessary.

The apparent places may be regarded as the sum of two terms: (1) the adopted mean place, and (2) the star correction. The first depends on previous observations generally selected from national sources, and is therefore different in different almanacs; but the second is a mere matter of computation, the elements for which are known with such accuracy that the results might be expected to agree very closely.

The original comparison referred to the years 1889 and 1890, and it was found that for these years the star corrections for

Polaris of the *N.A.* and *C.T.* did not show a satisfactory agreement. The *N.A.* was then compared with other ephemerides, and other years were examined, and the following notes of the results may be of interest.

Previous to 1875 the "terms depending on 2δ ," as they are generally called, were not incorporated in the printed star places of the *N.A.*, but a separate table was given to facilitate the application of these terms for the five circumpolars. The comparison with other almanacs for circumpolar places thus involves some labour, and it will be convenient to begin with the year 1875. From 1875 to 1887 the agreement between the places of the *N.A.* and the *C.T.* is quite satisfactory, the differences for right ascension of *Polaris* ranging over about $0^s.10$ throughout the year. A curious exception must be made of the first year (1875) itself, when these differences are so accurately constant as to make anyone who has had experience of independent computation somewhat suspicious. It may be remarked that the *N.A.* for 1875 was published in 1871, and the *C.T.* in 1873.

For these years then we may bracket the two almanacs together; and the remark made by Professor Auwers in the *B.J.* for 1884, Appendix, p. 92, will probably apply to the whole period 1875-1887. After stating that the *B.J.* and *A.E.* agree sensibly from the year 1883 onwards, he proceeds:—"The *N.A.* and the *C.T.* agree in their reductions. Both set down the principal lunar term in the formula, but neglect it in the computed values of A, B, C, D, and in the 10-daily ephemerides (for non-polar stars); but, besides this, they quite unnecessarily neglect sensible terms of long period, thus introducing errors amounting to $0''.25$. Without considering terms which up to 70° declination do not singly reach $0''.002$, the following corrections are thus applicable to the reductions from mean to apparent place as given in the *C.T.* and *N.A.*:—

$$\Delta(\Delta\alpha) = +0''.135 \sin(\odot + 82^\circ.2) - 0''.003 \sin 2\odot - 0''.046 \sin \delta,$$

$$+ 0''.059 \sin(\odot + 82^\circ.2) \sin \alpha \tan \delta,$$

$$- 0''.009 \cos(\odot + 280^\circ.9) \cos \alpha \tan \delta.$$

$$\Delta(\Delta\delta) = +0''.059 \sin(\odot + 82^\circ.2) \cos \alpha + 0''.009 \cos(\odot + 280^\circ.9) \sin \alpha."$$

It does not appear that any notice has been taken of this remark in these almanacs to the present time, so that computations based on these ephemerides require the corresponding small corrections—for instance, the places of the Greenwich Ten-Year Catalogue (1877-1886).

But there remains a curious discrepancy. From the year 1888 the agreement between the *N.A.* and *C.T.* for right ascensions of close circumpolars exists no longer, the range of difference for *Polaris* being more than $0^s.50$. The *N.P.D.s* are apparently unaffected.

The following table exhibits the range of discordance in apparent places of *Polaris* between the *N.A.* and *C.T.* for various years:—

Code No.	Year.	Range in R.A.	Range in N.P.D.
	1875	0°00	0°0
25301	1880	0°09	0°3
25302	1883	0°19	0°3
	1886	0°18	0°4
25303	1887	0°18	0°3
25304	1888	0°57	0°2
	1891	0°46	0°2

Concerning the reason for this discrepancy M. Lœwy kindly informs me that from 1888 the formulæ of Fabritius have been used in obtaining apparent places for the *C.T.*, and this change would appear to be an advantage on comparing the *C.T.* and *N.A.* respectively with other ephemerides. The following table shows the range of the differences in the apparent R.A.'s of the four circumpolars for the year 1890:—

			<i>B.J.-N.A.</i>	<i>B.J.-C.T.</i>
			^s	^s
25307	<i>Polaris</i> ...	...	0°45	0°12
25310	<i>Cephei</i> 51 ...	...	0°29	0°04
25311	δ <i>Ursæ Minoris</i> ...	...	0°21	0°04
	λ <i>Ursæ Minoris</i> ...	...	0°86	0°13

With regard to the N.P.D.s it may be questioned whether computation to one place of decimals is quite enough. It is apparently to this that we may trace the discordances ranging one or two tenths on either side of zero, which thus become sensible. The range corresponding to 0°'3 in right ascension of *Polaris* would be $0^s.3 \div 15 \sin N.P.D. = 0^s.9$, about which some care is taken in computation. There appears to be no reason for withholding the same care from N.P.D. computations; and this remark would apply to all stars.

Photograph of Stars in the region of Tycho's Nova.

By Isaac Roberts.

The photograph which accompanies this communication was taken on January 12, 1890, with an exposure of the plate during 2 hours and 55 minutes. The right ascension at the middle of the plate is about 0^h 16^m, and the declination north 63° 18'. Four pencil lines, enclosing a rectangular space, are drawn on the photograph, so as to correspond with the chart of this region made by D'Arrest in 1864, and the position of the *Nova*, as given by him, is shown marked by a white circle.

D'Arrest has charted the stars to the 16th magnitude, and the photograph, when examined with a magnifier, shows them to probably the 17th magnitude.

There is no appearance of either a nebula or of a star on the photograph in or about the position indicated by D'Arrest, namely, R.A. $0^h 17^m 7^s$, Decl. $+63^\circ 23'5$, but if we compare D'Arrest's chart and catalogue of the stars with the photograph, it will be seen that changes have taken place both in the positions and magnitudes of several of the stars since 1864. The following particulars will illustrate some of these changes; but they are not to be considered as a complete discussion of D'Arrest's chart. The stellar numbers and coordinates of the positions are those given by D'Arrest.

The star No. 15, R.A. $0^h 15^m 13^s$, Decl. $63^\circ 9$, is shown on the chart to be 13th magnitude, but on the photograph it is only about 17th magnitude.

The star No. 72, R.A. $0^h 16^m 20^s$, Decl. $63^\circ 13'$, magnitude 11-12, has changed in its position-angle to the extent of about 55° , from south following to south preceding the 11-12th magnitude star, No. 69, R.A. $0^h 16^m 17^s$, Decl. $63^\circ 14'$.

The double star No. 153, magnitude 14, R.A. $0^h 17^m 45^s$, Decl. $63^\circ 22'$, has changed its position-angle by moving towards the preceding side with reference to the star No. 159, magnitude 11-12, R.A. $0^h 17^m 51^s$, Decl. $63^\circ 23'$.

The 11th magnitude star, No. 83, R.A. $0^h 16^m 34^s$, Decl. $63^\circ 26'$, does not appear on the photograph.

The two stars, No. 100, R.A. $0^h 16^m 49^s$, Decl. $63^\circ 11'6$, and No. 97, R.A. $0^h 16^m 48^s$, Decl. $63^\circ 13'5$, have changed in magnitude from 11th to about the 16th.

The 12-13th magnitude star, No. 120, R.A. $0^h 17^m 12^s$, Decl. $63^\circ 50'$, has changed its position-angle by moving about 30° towards the south following direction.

The 11th magnitude star, No. 203, R.A. $0^h 18^m 52^s$, Decl. $63^\circ 27'4$, has changed in its position-angle about 35° towards the north following direction.

The 11th magnitude star, No. 37, R.A. $0^h 15^m 45^s$, Decl. $63^\circ 32'$, has changed its position-angle with reference to the star No. 36, magnitude 11, R.A. $0^h 15^m 44^s$, Decl. $63^\circ 34'$, from south following to south preceding.

The star No. 33, R.A. $0^h 15^m 40^s$, Decl. $63^\circ 36'$, magnitude 10-11, does not appear on the photograph.

The following group of four stars are not recognisable on the photograph, and no stars appear exactly where they are shown:—

Star No.	h	m	s	
3, R.A.	0	14	53,	Dec. $63^\circ 37'6$, 10-11th Mag.
4, "	0	14	53,	" $63^\circ 38'7$, 11th "
8, "	0	15	3,	" $63^\circ 37'6$, 11th "
12, "	0	15	8,	" $63^\circ 38'2$, 10th "

The changes which have now been particularised are important when we consider that they apply to less than half a degree in right ascension, and one degree in declination; but there are two causes of uncertainty to be taken into account before we can give full acceptance to the objective reality of these changes.

1st. Photographic magnitudes of stars do not all agree with those which have been determined by eye observations, and this fact may account for some of the differences in the magnitudes.

2nd. There may be errors in the charting by eye observations, notwithstanding the greatest care and skill on the part of the observer, but any uncertainties that may appertain to them, as well as to the subject matters of this communication, can now be removed by those who possess the necessary optical power; for the exact nature of the changes to be determined has been pointed out by photography, and the essential data furnished for the purpose. That the stars, Nos. 3, 4, 8, 12, 33, and 83, which have been referred to as shown on D'Arrest's chart, and not shown on the photograph, are absent on the latter on account of some physical change having taken place in the stars, receives confirmation by the fact that the photograph shows more than 400 stars on a sky space where D'Arrest has charted only 212 stars.

I am indebted to Dr. Pechüle, of Copenhagen, for a copy of D'Arrest's chart and catalogue, and he informs me that he has for some years kept a watch upon the region of the *Nova*.

Note on the Sun-spots of 1889. By E. W. Maunder.

Though the Sun-spots of 1889 were few in number and generally small in area they presented some characteristics of especial interest; for the past year saw the close of one cycle of solar activity and the commencement of a new one, and the peculiar features of a transition period were well illustrated by the spot-groups which came under observation.

General Features of the Sun-spot Record of 1889.

From every point of view 1889 was a less fertile year than those which preceded it. Without going back to 1884 or 1885—years of great activity—it may be useful to compare it with 1886 and the two succeeding years, for in 1886 there was a lull of so pronounced a character in the late autumn as to lead one experienced solar observer to regard it as probably the true minimum. The following table shows how 1889 compares with the years preceding it as to days without spots, number of spot-groups observed, and mean daily spotted area:—

Year.	Days of Observation.	Days without Spots.	No of Spot-groups.	Mean Daily Spotted Area.
1886	363	61	128	381
1887	361	106	79	179
1888	358	155	54	89
1889	359	209	32	77

The areas in the above and in the following tables are expressed in millionths of the Sun's visible hemisphere.

There can be no doubt, therefore, that the minimum did not fall before 1889.

Duration of Spot-groups.

A marked feature of the spot-groups of 1888 had been the tendency of the disturbances to be intermittent. Amongst the fifty-four spot-groups of that year there was not a single case of a group being seen through the whole of three semi-rotations, nor even through the whole of two; though in one instance a group was seen during part of three successive rotations, and in another case a group was seen during part of two successive rotations. These were the only two examples of a group returning to the east limb after its disappearance at the west limb. But whilst the continuous life-history of a group tended to be short, there were several cases—nine in all—in which a district was the seat of an intermittent action, an interval of rest prevailing between the different outbreaks. The following table shows the localities in which this intermittent action was observed:—

No. of Group.	First Seen.	Last Seen.	Hel. Long.	Hel. Lat	Mean Area.
2075	Nov. 11	Nov. 22	15°6	— 4°0	193
2077	Dec. 9	Dec. 9	19°7	— 3°7	9
2043	March 31	March 31	142°2	— 1°0	7
2050	April 25	April 29	144°8	— 1°5	15
2064	Aug. 12	Aug. 22	143°5	— 2°6	29
2030	Jan. 12	Jan. 16	148°6	— 13°3	24
2049	April 24	April 29	153°4	— 13°3	47
2055	June 19	June 19	163°4	— 12°7	11
2070	Sept. 6	Sept. 16	163°8	— 14°9	57
2072	Oct. 3	Oct. 3	166°8	— 14°5	22
2076	Nov. 27	Dec. 9	163°3	— 11°8	217

Group 2064 was not seen on August 17, nor on August 19 and 20.

2048	April 21	April 27	184°3	— 2°8	36
2069	Sept. 6	Sept. 10	185°8	— 0°3	16

Group 2069 was not seen on September 9.

No. of Group.	First Seen.	Last Seen.	Hel. Long.	Hel. Lat.	Mean Area.
2047	April 18	April 18	243°5	- 6°7	15
2051	April 28	April 28	247°4	- 7°5	5
2054	June 15	June 19	257°8	- 10°0	30
2059	July 10	July 17	266°2	- 10°1	65

Group 2059 was not seen on July 12.

2052	May 11	May 23	273°5	- 7°8	443
2058	July 6	July 7	272°6	- 6°9	10
2063	Aug. 8	Aug. 10	274°5	- 8°1	28
2066	Aug. 28	Sept. 9	276°7	- 6°1	248
2035	Feb. 18	Feb. 29	297°3	- 4°7	220
2042	March 25	March 25	299°0	- 4°6	3
2053	June 9	June 16	301°9	- 4°6	52
2062	Aug. 1	Aug. 2	304°9	- 5°8	17
2068	Aug. 31	Aug. 31	301°7	- 3°3	10

A tenth group, group 2060, was lost for a single day (July 18). Longitude 150°·3, latitude +6°·0.

In marked contrast to this tendency to intermittent action shown by the spot-groups of 1888 we find in 1889 only four examples, two of them but very slightly marked, in which spots broke out a second time in a district after an intervening period of rest. But whilst the examples of this intermittent action were fewer and less distinct than in 1888, there was an increased tendency to more persistent displays.

The following table shows the duration of the different groups during the last four years. It will be seen that with a total of thirty-two groups as against fifty-four in 1888, the number of groups seen in a second or third rotation was twice as large in 1889 as in the preceding year:—

Duration of Group.	Number of Groups.			
	1886.	1887.	1888.	1889.
1 day	20	11	12	4
2 days	17	9	9	6
3 "	17	9	5	3
4 "	7	9	2	0
5 "	6	7	4	1
6 "	6	5	1	2
7 "	4	3	2	2
8 "	6	2	3	0
9 "	1	2	1	1
10 "	1	5	0	1
11 "	5	2	4	1
12 "	8	3	3	0

Duration of Group.	1886.	1887.	1888.	1889.
13 days	1	2	3	1
14 "	0	1	0	0
2 rotations	6	5	1	2
3 "	3	0	1	2
4 "	1	0	0	0
5 "	1	0	0	0
Total No. of groups	128	79	54	32
Total No. of separate groups, } deducting for reappearances }	110	75	51	26
Mean observed duration of a group	10 days	7 days	6 days	11 days

The following table gives the four regions where intermittent action was observed in 1889 :—

No. of Group.	First Seen.	Last Seen.	Hel. Long.	Hel. Lat.	Mean Area.
2081	Feb. 1	Feb. 6	31° 9'	— 3° 5'	60
2090	June 16	June 28	30° 7'	— 5° 5'	501

Group 2090 was seen in the two succeeding rotations as groups 2092 and 2099.

2093	July 14	July 20	84° 4'	— 7° 7'	33
2098	Aug. 9	Aug. 17	79° 5'	— 7° 2'	335
2101	Sept. 3	Sept. 4	83° 6'	— 9° 4'	7
2103	Sept. 24	Oct. 4	152° 5'	— 20° 9'	141
2107	Oct. 23	Oct. 23	154° 1'	— 22° 5'	2

Group 2103 had been seen in the two preceding rotations as groups 2097 and 2100.

2087	April 11	April 12	203° 0'	— 1° 2'	15
2096	July 29	Aug. 4	200° 5'	— 0° 9'	64

Distribution in Latitude.

The most striking feature of the spot-groups of 1889 was the appearance of a number of spots in high latitudes. In accordance with their behaviour in previous cycles the spots had tended to approach more and more nearly to the equator from the time of the previous minimum in 1879.

Year.	Mean Distance from Equator of all Spots.	Year.	Mean Distance from Equator of all Spots.
1879	22° 82'	1884	11° 27'
1880	19° 80'	1885	11° 76'
1881	18° 21'	1886	10° 38'
1882	17° 81'	1887	8° 44'
1883	13° 04'	1888	7° 39'

In 1888 only one spot out of the fifty-four groups had a higher latitude than 15° , and that spot lasted but for a single day; but ten lay between 15° and 10° , whilst the remaining forty-three clustered still nearer to the equator. The downward tendency was continued in 1889. Up to June 29 no spot had a higher latitude than 10° , and throughout the year there was only one instance of a group lying within either of the zones 20° to 10° , and in that case it was only for a part of its duration that its latitude was less than 20° ; its mean latitude on the whole being $20^{\circ}5$ S. But in the latter half of the year there were several instances of groups in latitudes higher than 20° , so that the groups of 1889 were divided into three well-defined and widely separated zones—a high northern zone, an equatorial zone, and a high southern zone, with a barren belt 10° wide separating the equatorial zone from the zones of high latitude on either hand.

We may look upon the equatorial zone as containing the last remains of the spots of the expiring cycle, whilst the high zones show the first efforts of the new cycle.

	Mean Daily Area of Sun-spots.			Total.
	Under 10° .	10° to 20° .	Above 20° .	
1886, Jan.—June	352	255	1	608
July—Dec.	100	59	1	159
1887, Jan.—June	84	49	0	134
July—Dec.	194	29	0	223
1888, Jan.—June	89	4	0	93
July—Dec.	66	20	0	86
1889, Jan.—June	53	0	0	53
July—Dec.	52	0	51	103

The southern hemisphere has still preserved that predominance which it has shown, almost without break, ever since the closing up of the great northern spot of November 1882.

	Equatorial Zone.		Above 20° Lat.	
	No. of Groups.	Mean Daily Area.	No. of Groups.	Mean Daily Area.
Northern	4	4	2	1
Southern	16	48	10	25

Distribution in Longitude.

In years of minimum such spots as appear are usually confined to two or three limited areas. This was very remarkably the case in 1889. The great group of June 16 in its three appearances as groups 2090, 2092, and 2099 contributed more than 41 per cent. of the spotted area of the year, or, including the preliminary outbreak in the same region in February, 42 per cent. The great group of August 2 made up 26 per cent. in its successive appearances as groups 2097, 2100, and 2103. These

two groups, therefore, embraced between them about 68 per cent. of the entire spotted area. The region of longitude 83° and latitude -8° came third with 12 per cent., so that all the other groups put together contained but little more than 20 per cent.

Localities of Formation and Dissolution.

Of the twenty-six separate groups of the year, eighteen formed and dissolved in the visible hemisphere, and were seen only in one rotation; three formed and dissolved in the visible hemisphere, but were seen in more than one rotation; two formed on this side of the Sun, but were dissipated on the other; one formed on the other side, but was dissipated on this; and two, of which one was seen only in one rotation, but the other in three, formed and dissolved in the unseen hemisphere.

Dividing the visible hemisphere into thirteen lunes, each $13^{\circ}2'$ of longitude in breadth, so that each lune corresponds to the mean apparent distance traversed by a spot in a single day, and placing the seventh so that the central meridian should bisect it, the number of cases of spot-formation and spot-dissolution for each lune or day are as follows:—

Lune or Day.	Formations.	Dissolutions.	Ephemeral Spots.	Total No. of Separate Spots.	Total Area.
First	0	0	0	9	1293
Second	1	0	0	13	1695
Third	5	0	1	33	1866
Fourth	2	2	0	50	1756
Fifth	2	1	1	76	1806
Sixth	2	2	0	65	2242
Central	1	0	0	72	2459
Eighth	0	1	1	102	2527
Ninth	1	2	0	102	2407
Tenth	2	1	0	73	2568
Eleventh	2	1	0	50	2642
Twelfth	0	8	0	34	2701
Thirteenth	1	0	1	14	1720

It will be seen that neither the total spotted area nor the number of separate spots was divided symmetrically with respect to the central meridian, the western quarter-sphere having a most distinct advantage over the eastern in both particulars. On the other hand, more groups formed to the east of the central meridian, and more were dissipated to the west of it; the third day being the most favourable for spot-formation, and the twelfth for their extinction. But the number of groups under observation in either quarter-sphere was nearly the same; seven groups being seen only in the east, and nine only in the west, whilst six-

teen were observed on both sides of the central meridian. The preponderance of number of spots and of spotted area observed in the western half of the visible hemisphere was therefore due to the tendency of groups to increase in size and complexity after the central meridian was passed.

Though the example of a single year, and that a year of minimum, is wholly insufficient to base any deductions upon, it will be at once recognised that if a long series of years showed any similar want of symmetry in spot-distribution, it would lead us to the conclusion that our Earth exercised a real influence over the behaviour of the spot-groups, and would render it highly probable that *Venus* and *Jupiter* exerted an influence considerably greater, whilst the establishment of a practical symmetry over a term of years would disprove the existence of any appreciable planetary influence at all. It seems to me, therefore, that this is a point for very careful investigation in the future. The want of symmetry in the present instance may, I think, be regarded as purely accidental, being due to the sudden revival of activity on the ninth day in the case of two important groups, and to the formation of another considerable group at the same apparent meridian.

Characteristics of Spot-groups.

Thirteen of the groups of 1889 were seen only on one, two, or three days. Of these, twelve were but small in size and presented no important peculiarities, except that of position; six of them lying in high latitudes as under:—

No. of Group.	First Seen.	Last Seen.	Hel. Long.	Hel. Lat.	Mean Area.
2091	June 29	June 30	251°1	−40°3	5
2094	July 26	July 27	342°1	−24°2	66
2104	Oct. 8	Oct. 8	12°1	−28°8	12
2105	Oct. 9	Oct. 11	23°4	−25°3	8
2106	Oct. 16	Oct. 18	328°9	+22°3	15
2107	Oct. 23	Oct. 23	154°1	−22°5	2

The thirteenth group, group 2102, was distinguished by the development of a large spot in advance of the rest of the group, on the last day on which it was visible before passing out of sight at the west limb. The group followed group 2100 on the same parallel of latitude but at a distance of about 10° in longitude, and there appeared to be a species of attraction between the two groups, the preceding group moving backwards, and the following group forwards. It is far more common to see examples of apparent repulsion.

Of the remaining thirteen groups the five following consisted

of a number of small spots irregularly scattered. In each case the group underwent very rapid changes, increasing to a maximum in two or three days, and then fading away almost as quickly.

Group.	First Seen.	Last Seen.	Hel. Long.	Hel. Lat.	Mean Area.
2081	Feb. 1	Feb. 6	31°9	— 3°5	60
2082	Feb. 22	March 3	111°9	— 7°1	55
2093	July 14	July 20	84°4	— 7°7	33
2096	July 29	Aug. 4	200°5	— 0°9	64
2109	Dec. 18	Dec. 22	168°1	+ 24°1	34

One group, group 2088, consisted of a large circular spot, which broke up on the third day into a stream of small spots. The course of a number of groups as watched in the visible hemisphere suggests that this group had been in existence some ten or twelve days before its appearance at the east limb.

Three groups, groups 2083, 2098, and 2110, illustrate to some extent a type of spot-history often witnessed amongst the more important groups, but three of the four groups of long duration afford much better examples of it. In this type of spot the outbreak commences with a few small faint spots very irregularly distributed. By the second or the third day a great change has taken place; there is a strong forward motion in the group; the spots tend to arrange themselves in a long straight stream, generally along or but slightly inclined to a parallel of latitude. The spots rapidly increase in number and size, especially towards the two ends of the stream. Soon the group consists of two large spots with a few much fainter and smaller spots between them. Of the two large spots the leader is usually the larger, is very regular and well defined in outline, and for a time moves forward very rapidly in longitude. The last spot of the group is nearly stationary, not so regular in shape, and soon breaks up. The fainter and smaller spots in the centre of the group disappear, leaving the two principal spots alone. The following spot after breaking up soon disappears also, and the leader is left alone. The lifetime of the leader as a solitary circular spot is of very various duration, sometimes only a day or two, sometimes it continues through several complete rotations. It disappears either by breaking up into small fragments, or, preserving its shape, gradually contracts until nothing is left.

Of the four long-duration groups of the year, the group seen in two rotations as groups 2108 and 2111 was a single circular spot. The other three groups, the positions of which are given below, are examples of the type of spot just described:—

Group.	First Seen.	Last Seen.	Hel. Long.	Hel. Lat.	Mean Area.
2085	March 13	March 17	308°2	+ 6°2	110
2086	April 1	April 11	315°1	+ 5°3	71
2090	June 16	June 28	30°7	- 5°5	501
2092	July 12	July 24	36°3	- 7°9	318
2099	Aug. 9	Aug. 20	36°9	- 8°1	73
2097	Aug. 2	Aug. 11	161°5	- 20°7	336
2100	Aug. 27	Sept. 7	160°4	- 19°3	198
2103	Sept. 24	Oct. 4	152°5	- 20°9	141

All three groups were distinguished by the remarkable manner in which they moved about on the solar surface, not only in longitude but also in latitude.

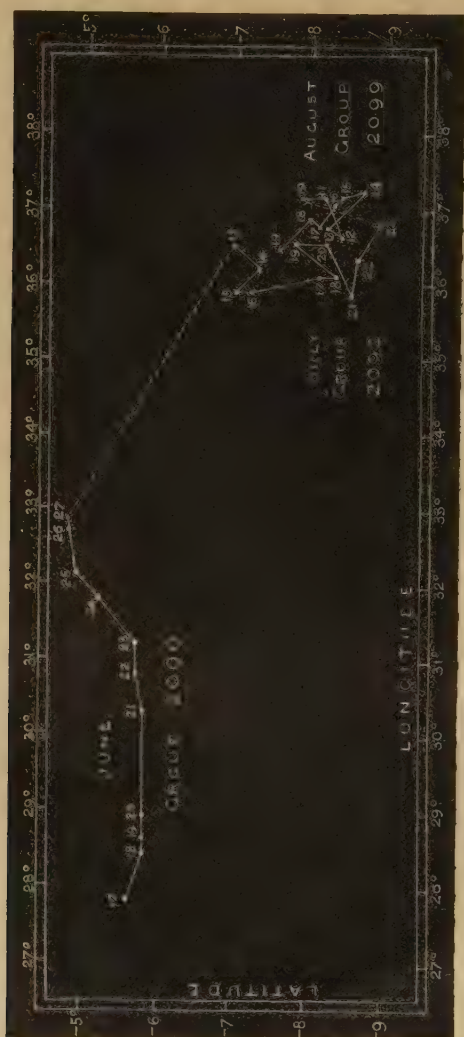
The first group moved forward $5^{\circ}2$ in longitude, and $0^{\circ}6$ upward in latitude, in the four days following its formation. In the fortnight that it was on the further side of the Sun it moved forward $4^{\circ}0$ in longitude, and $1^{\circ}1$ downward in latitude. It was now a single circular spot, and remained nearly stationary till its disappearance.

The second group, that of June 16, the principal group of the year, showed the most extraordinary drift, as the first diagram will show.

Some of the minor irregularities are probably due to faculous or photospheric matter drifting above portions of the group and concealing certain districts of it, revealing them again by their withdrawal later on. But as for the greater part of its history, the group practically consisted of but one well-defined circular spot, there can be no doubt that the apparent change of place from day to day corresponds very closely to the real movement of the centre of the group upon the solar surface. In this and in the second diagram the observed positions for the first and last days at each appearance are not given, as only a portion of the group was visible on some of those occasions, and the centre of the part observed was therefore not the true centre of the group.

The third group of long duration, that of August 2, was a very perfect example of the type above described. The first faint spots were seen on August 2. By August 4 the long stream of spots with a large spot at either end had fully formed; and by August 11 the leader alone remained. During the next rotation the group consisted only of one large circular well-defined spot. At its third appearance this circular spot was preceded by a number of small spots, but after September 26 the entire group, and especially the smaller spots, began to diminish, and the group had disappeared before reaching the west limb. The most striking feature in the history of the group was the rapid backward drift shown after its first appearance. The forward movement during the first rotation, the retrogression whilst on the

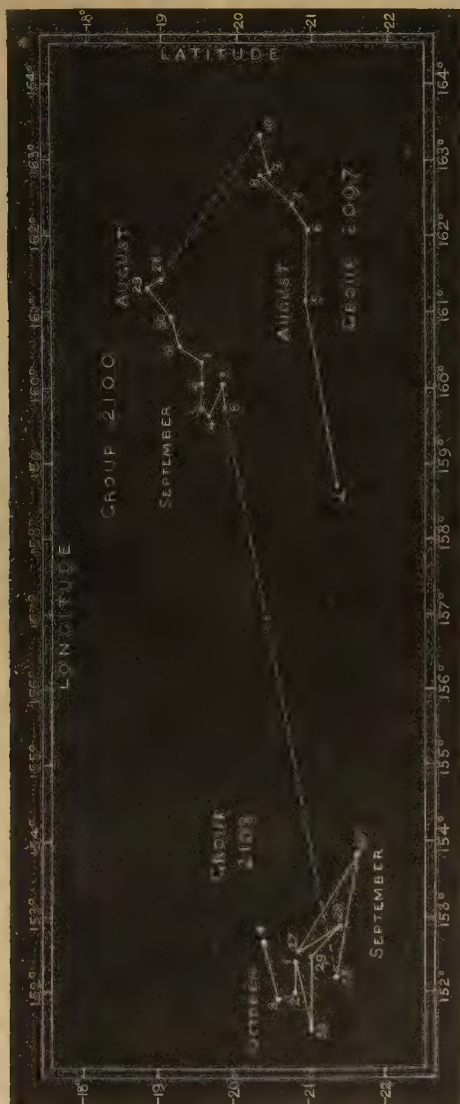
further side of the Sun, and during the second appearance, and the irregular drifting shown in the third illustrate well the difficulty in obtaining any trustworthy rotation period. This



one group would have given three very different rotation periods from its three different appearances, viz. 24.1 days, 25.8 days, and 25.5 days. Carrington's period for this latitude would be 25.7 days. The rotation-period adopted in this paper for the

computation of the heliographic longitudes has been 25.38 days throughout.

The following diagram shows the apparent course of the group during the three appearances.



Summary.

The chief features of the Sun-spots of 1889 are:—

1. The Sun-spots were fewer and smaller than in 1888.
2. But the second half of 1889 was more prolific than the first half.
3. In the second half of the year several spot-groups appeared in high latitudes, so that the spots were congregated in three distinct zones.
4. The average duration of a group was double what it was in 1888. There was less tendency to intermittent action, and a greater tendency to continued action.
5. Some of the larger groups showed a drift remarkable for rapidity and irregularity.

A Mechanical Theory of the Solar Corona. By J. M. Schaeberle.

(Communicated by E. B. Nobel.)

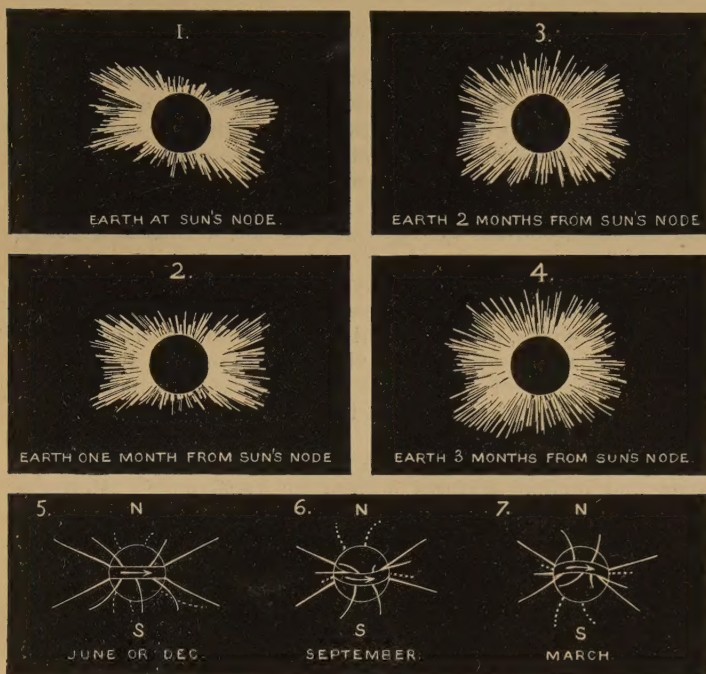
My investigations seem to prove conclusively that the solar corona is caused by light emitted and reflected from streams of matter ejected from the Sun by forces which, in general, act along lines normal to the surface. These forces are most active near the centre of each Sun-spot zone.

On account of the rotation of the Sun the nearer portions of the stream will have a greater angular velocity than the more distant parts, resulting in a stream of double curvature, each individual particle of the stream, however, describing the same conic section, which for velocities less than about 383 miles per second is a very eccentric ellipse (assuming that the Sun's atmosphere is very rare, as is apparently shown by various observations).

Owing to the change in the position of the observer with reference to the plane of the Sun's equator (according as he is above, below, or in this plane), the perspective overlapping and interlacing of the two sets of streamers causes the observed apparent change in the type of the corona.

In the diagrams numbered 5, 6, and 7 I have purposely exaggerated the curvature of the streams in order to show more forcibly the perspective effect when viewed from different parts of the Earth's orbit. All the other illustrations are prints made from the same model, in which the Sun is represented by a ball something over an inch in diameter, from which radiate a number of needles to represent the streams of matter. All these needles are contained between two small circles corresponding to 30° of north and south latitude, the longer ones being found near the middle of each zone, and slightly more inclined to the normal than the shorter ones, in order that the more distant portions of

the needles (representing the outgoing streams) shall have inclinations roughly the same as required by physical laws.



When the model is placed in a beam of parallel rays and its shadow allowed to fall upon a screen, an infinite variety of forms can be produced by simply revolving the model, although an effort was made to secure a symmetrical arrangement of the needles in the two zones.

The illustrations show the changes due to the apparent variation of the inclination of the Sun's axis to the line of sight.

No. 1 Earth at Sun's node.

2 Earth one month from Sun's node.

3 „ two months „ „

4 „ three months „ „

A discussion of the mechanical theory, together with a comparison showing the remarkable agreement with observation, will appear in the report of the eclipse of December 22, 1889.

Mount Hamilton:
1890 March 18.

The Structure of the Sidereal Universe. By T. W. Backhouse.

(Abstract.)

Curves of stars have often been noted in the heavens, but less attention has been paid to what the writer has found to be a far more striking and prevalent feature, of which this paper more especially treats—*straight* lines and *parallel* arrangements of pairs, lines, and bands of stars, and also of irresolvable wisps.

A special small area of the sky, viz. that portion of the Milky Way included between 15, 13, 8 *Monocerotis*, α *Orionis*, ζ *Tauri*, and 5, μ , ξ *Geminorum*, has been selected for detailed scrutiny; and the descriptions refer chiefly to the configurations in this area. The observations have been made by the author during the last eight years, and nearly all of them at Sunderland; some are features noted by unaided vision, but most of them were gleaned by the use of a binocular field-glass of 2.05 inches aperture; a refracting telescope of $4\frac{1}{4}$ inches aperture being occasionally used.

The details are exhibited in tabular form in the original paper, and include features noticed in Argelander's *Atlas des nördlichen gestirnten Himmels*. Though the field-glass shows nearly as many stars as the maps, the same features are not always found, two suggested reasons for this being that stars separately too faint to be inserted in the maps may be impressed upon the eye by their united light; and, on the other hand, the appearance of a line may be destroyed by surrounding stars. Proctor's chart of the whole of Argelander's stars was also examined for comparison, and for the great cluster in *Gemini* the MM. Henry's photograph of that object.

The paper contains the following sections:—

Part I.—Lines and parallel arrangements of stars.

Part Ia.—Lines and parallel arrangements in clusters.

Part II.—Nebulous wisps.

Part IIa.—Nebulæ.

In these are given the detailed structure in different parts of the area, showing the various systems of parallel lines and wisps, together with their position-angles referred to that portion of Gould's Galactic Equator (vide *Uranometria Argentina*, p. 371), which runs through the middle of the area in question. For comparison are also given the position-angles, referred as above, of several well-recognised circles in the heavens as

Part III.—Miscellaneous lines.

Many of the details described are obvious on the most casual glance, and nearly all are conspicuous on careful scrutiny.

There is, besides the parallelisms, a most wonderful case of

radiation of stars and wisps in a fan-shaped group, 68 *Orionis* being approximately the centre. The only counterpart to this which the author has seen is one on a far larger scale, visible to the naked eye, but much less striking; viz. a radiation from near the Pole star to the Milky Way in the semicircle from ϵ *Ursæ Minoris* to β *Camelopardi*.

Two maps and five figures accompany the paper; the latter exhibit the groupings of the various position-angles, showing a preponderance at an average deviation of 15° from the direction of Gould's Galactic Equator, viz. at a position-angle of 345° with that great circle, and more nearly parallel with a Galactic Equator derived from Proctor's chart of the *Durchmusterung* stars. There is a marked deficiency of position-angles at right angles to the Galactic Equator of those in the great cluster 35 *Messier*, as well as of the wisps.

The terms "nebulous wisps" and "nebulosity" have been given to that faint and diffused luminosity, usually in long and narrow bands, which when viewed with higher powers is sometimes resolved into stars, sometimes remains partially or wholly unresolved, and sometimes disappears altogether. When resolved, it in some cases shows very small and densely packed stars, in others widely scattered stars not much too faint to be individually visible with the lower power.

One conclusion derived from the investigation is that the stars and wisps in parallel lines are probably in the same region of space; and therefore that the majority of the stars—at least of those down to the 9th or 10th magnitude—in extensive tracts of the area examined are really near one another.

The paper is offered as a contribution to a subject till lately much neglected, in the hope that the observations will be supplemented by those of others, whether in confirmation or otherwise.

Discovery of Comet Brooks 1890. By William R. Brooks.

I have the honour to announce to the Society my discovery, on March 19, 16 hours (standard, 75th meridian time), of a new comet in approximate R.A. $21^h 9^m$, Dec. $+5^\circ 35'$. I at once felt confident that the object was a comet, for the region has been thoroughly searched many times, and I had no record of a nebula in that place. On turning to Dr. Dreyer's "New General Catalogue of Nebulae," published in the *Memoirs* of the Royal Astronomical Society, it was found that the nearest nebula recorded there was No. 7045 = J.H. 2108, which was 2° away, and marked ϵ F, while my object was quite bright. The morning dawn advanced rapidly, however, and obliterated the object before I was positive of motion, but suspected a slight motion northward. The Harvard, Lick, and Warner Observatories

were therefore promptly notified of the suspected object, with a request to verify. With myself the three succeeding mornings were tantalisingly cloudy. On the fourth morning, however, March 23, at 16 hours, it was beautifully clear, and turning the telescope to the place I at once found the comet less than one and one half degrees north, and slightly east of the discovery position, and in approximate R.A. $21^{\text{h}} 10^{\text{m}} 30^{\text{s}}$, Dec. $+ 7^{\circ} 15'$. This gave a daily motion of 22° east, and $25'$ north. The two telescopic fields are shown in figs. 1 and 2, fig. 1 being the field of discovery.



1. Discovery field of Comet Brooks,
1890 March 19^d 16^h.



2. Telescopic field of Comet Brooks,
1890 March 23^d 16^h.

The comet is rather bright, telescopic, with stellar nucleus, and a short, broad tail. The discovery was made with the $10\frac{1}{2}$ -inch refractor, with a chromatic positive eyepiece, giving a mag. power of 40, and a field of $1^{\circ} 20'$.

Smith Observatory, Geneva, N.Y., U.S.A.:
1890 March 24.

Erratum.

In Dr. Spitta's paper, page 323, second paragraph, line 4:—

For ratio of 1 : 6.40 read ratio of 1 : 16.40.